1970

The Effects of Selected Training Intensities and Durations on Blood Cholesterol and Selected Anthropometric Measurements

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THE EFFECTS OF SELECTED TRAINING INTENSITIES AND DURATIONS ON BLOOD CHOLESTEROL AND SELECTED ANTHROPOMETRIC MEASUREMENTS

BY

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A thesis submitted in partial
fulfillment of the requirements for the degree
Master of Science, Major in Health, Physical Education,
and Recreation, South Dakota
State University

1970

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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ACKNOWLEDGEMENTS

The investigator would like to express sincere thanks to Dr. Paul Brynteson for his guidance and assistance in developing and writing this thesis, and to Associate Professor Glenn E. Robinson for his help and moral support throughout the project.

Appreciation is extended to Dr. Lee W. Tucker, Associate Professor of Agriculture and Biological Sciences, for his valuable statistical assistance. The writer would also like to express his appreciation to the fifty-five subjects whose cooperation made this study possible.

A special thanks is due the author's wife, Ingrid, and son, Michael, for their understanding and cooperation throughout the project.

A.I.M.

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INTRODUCTION

Significance of the Study

Physical inactivity, due to automation and our busy mode of living, has contributed to a health problem in modern society. When obesity, high-fat diets, cigarette smoking, and stress are added, the end-product is an alarming increase in incidence of diseases of the heart and lungs.[1] Admittedly, such diseases are multifactoral in cause, but inactivity appears to assume an increasingly important role. In a fitness statement by the American Association for Health, Physical Education and Recreation it was stated:

> Although man's need for survival has changed, his biological design has not. He is still meant to be an active, not a sedentary individual. Modern man has a critical choice, either he includes in his life vigorous activities or suffers losses. If he chooses to remain fit, he must elect those activities and practices that lead to this end.[2]

Exercise in relation to preventative and rehabilitative medicine, however, is a new and rapidly changing field of research. Consequently, the knowledge concerning physical conditioning and training programs is limited and inadequate. Therefore, educators in health and physical education are expected to apply modern scientific techniques and provide the much needed data.

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[1]Kenneth H. Cooper, "The Role of Exercise in Our Contemporary Society," Journal of Health, Physical Education and Recreation, 40:22, May, 1969.

[2]American Association for Health, Physical Education and Recreation, "Fitness for Youth," Journal of Health, Physical Education and Recreation, 27:8-9, December, 1956.

Physical fitness in this study implies cardiovascular-pulmonary fitness, which is, in short, circulatory and respiratory systems that are in good condition. Without adequate reserves in the cardiovascular-pulmonary systems, a person is not prepared to meet the common or unusual stresses of daily living. With exercise the heart becomes stronger and larger with an increased ability to deliver more blood with each stroke, both at rest and during exercise. There is also an improvement in the vascular system, specifically in the collateral blood supply to the heart, which lessens the likelihood of succumbing to an occlusive heart attack. Exercising subjects tend to feel better, look better, and, as a result, improve their self-image.[3]

The concept of physical fitness, however, is not without problems. In our busy, fast-moving society of today, people often find it difficult to allot regular periods of time for exercise. When they do have some spare time, they often desire to spend it in a sedentary manner, which is an unfortunate situation because sedentary use of leisure time eventually leads to deterioration of the body systems. Some deterioration is obvious, but many important deteriorations are not recognized outwardly. Noticeable are the increasing fat deposits on certain areas of the body and thus an increased body weight. Not so noticeable, however, is the increasing amount of cholesterol in the blood, which is one of the primary causes of atherosclerosis. The increasing combination of cholesterol, body weight, and body fat can be dangerous as it greatly

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[3]Cooper, op. cit., p. 23.

increases an individual's susceptibility to arterial and cardiac disorders. Therefore, it is imperative that a physical conditioning program be designed wherein the subjects can develop and maintain good cardiovascular-pulmonary fitness with a minimum of physical activity. Skinner supports this idea and has stated:

> More research is definitely needed to fill the gaps in our knowledge concerning the optimal amount of exercise required to elicit a training response. What is also needed is information on the minimal amount of activity needed to induce and maintain an adequate level of cardiovascular fitness.[4]

Information on a minimal exercise program will benefit not only those who find it difficult to fit exercise time into their schedule, but also the person who may become discouraged and cease exercising altogether if he finds it to be too difficult and unpleasant.

Statement of the Problem

The purpose of this study was to investigate the effects of various training intensities and durations on blood cholesterol, percentage body fat and body weight. (A concurrent study was conducted where the parameters of maximal oxygen uptake, maximal oxygen pulse, maximal pulmonary ventilation, maximal heart rate, ventilation equivalence for oxygen, and forced expiratory volume in one second were studied.)[5]

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[4] J. S. Skinner, "Commentary," Canadian Medical Association Journal, 96:900, March, 1967.

[5] J. A. Swisher, "The Effect of Selected Training Intensities and Durations on the Improvement and Maintenance of Cardiorespiratory Fitness" (unpublished Master's thesis, South Dakota State University, Brookings, 1970).

Hypothesis

The following hypothesis was investigated:

1. There is no significant difference in the changes in blood cholesterol, percentage body fat, and body weight among the six groups as a result of the conditioning program.

Limitations of the Study

1. The subjects were fifty-five male volunteers from the freshman basic instruction classes in physical education at South Dakota State University.
2. Only the bicycle ergometer was used as an exercise device for the present study.
3. The duration of the training period was ten weeks.
4. The outside physical activity of the subjects was controlled only to the point of agreement between the investigator and the subjects that they participate in as little physical activity as possible outside the study.

Definition of Terms

Conditioning period. The conditioning period consisted of a ten-week exercise program involving work on a bicycle ergometer at various intensities and durations. The terms "training" and "conditioning" are synonymous in this study.

Intensity of exercise. This refers to the degree of difficulty of the exercise. In this study, work loads were performed at either 70 or 80 per cent of the subject's maximal heart rate.

Duration of the exercise. The duration of the exercise is the length of time spent by the subject performing the exercise on each training day. The investigator used three durations: ten, twenty, and thirty minutes.

Percentage body fat. Percentage body fat is the weight in pounds of a subject's body tissue that is in excess of his lean body weight. In this study, percentage body fat is expressed as a percentage of the subject's total body weight.

Cholesterol. Cholesterol is a fat-like substance that is insoluble in water and easily dissolved in fat solvents. Cholesterol can exist under two conditions, free or combined with ordinary fats. Mathews attributes to it the following functions: "Transport vehicle for fatty acids, structural unit for some tissues, skin lubricant, or a precursor of such steroids as bile acids and sex hormones."[6]

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[6]Donald K. Mathews, Ralph W. Stacy, and George N. Hoover, Physiology of Muscular Activity and Exercise (New York: The Ronald Press Company, 1964), p. 338.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

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REVIEW OF THE RELATED LITERATURE

In order to facilitate a more organized and complete review of the related literature, two areas have been reviewed: (1) literature relating to general cardiovascular conditioning, and (2) literature relating to cholesterol, body weight, and percentage body fat. The purposes of reviewing the related literature were to provide insights into the methods and procedures of other studies similar to the present study, to provide useful information, to provide a sample of various opinions, and to provide data for comparative purposes.

Literature Relating to General Cardiovascular Conditioning

There has been a vast amount of research completed on numerous subjects within the area of cardiovascular conditioning. This section presents information on the effects that various training programs have on cardiovascular conditioning.

McNair conducted an investigation to ascertain the effects of different exercise programs on the development of cardiovascular fitness, strength, and muscular endurance. One hundred and twenty male subjects from the basic physical education classes were randomly divided into four groups. All subjects participated in regular physical education classes and were assigned additional exercises for the training period. Group I was assigned five minutes of interval running; Group II was assigned a two and one-half minute stepping exercise; Group III, isometric exercises; and Group IV served as the control and participated only in the basic instruction classes. Before the training period of six weeks began, all subjects were tested for their initial levels of cardiovascular endurance, leg strength, and muscular endurance of the legs. After the training period of six weeks was completed, the subjects were tested again. McNair concluded that significant gains in cardiovascular fitness, strength, and endurance can be brought about by placing the individual under sufficient stress. He also states that the nature of the conditioning program is not the important consideration as long as it is sufficiently strenuous.[7]

Durnin and colleagues investigated the effects of short periods of training of varying severity on measures of physical fitness. Forty-four men were randomly assigned to four groups for the training program. Before the training program began, the subjects were pre-tested on a standard treadmill test for various parameters of physical fitness. The training period consisted of ten days of walking over a predetermined course. Group I was the control and did not walk, Group II walked ten kilometers per day, Group III walked twenty kilometers per day, and Group IV walked thirty kilometers per day. After five days of training, the subjects were given the same treadmill test and, again, at the conclusion of ten days of training. It was found that the group of men walking twenty kilometers per day showed the most marked improvement in fitness. These subjects had a significant lowering of pulmonary

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[7]Daniel P. McNair, "Effects of Different Exercise Programs on the Development of Cardiovascular Fitness, Strength, and Muscular Endurance" (unpublished Doctor's dissertation, Louisiana State University, Baton Rouge, 1957), pp. 1-99.

ventilation, oxygen consumption, and heart rate during the test.[8]

Jackson and associates studied cardiorespiratory adaptations to training at specified frequencies. Twenty male undergraduates from the University of Montana were randomly divided into five groups and given three pre-tests. The subjects were tested for maximum oxygen uptake, performance on Balke's Treadmill Test, and performance on the Astrand-Ryhming Test. The training program involved running on a treadmill at seven miles per hour for ten minutes at different grades for five weeks. As the subjects' condition improved, the treadmill grade was increased. Group I exercised one day per week; Group II, two days per week; Group III, three days per week; Group IV, five days per week; and Group V acted as the control by playing volleyball three days per week. Upon completion of the five-week training program the subjects were post-tested on the same tests. The analysis indicated that significant differences existed between Group I and all the other groups. No other differences were significant; however, training two or three days per week seemed to be as effective as training five days per week.[9]

Brynteson studied the effect of various training frequencies on the retention of cardiovascular fitness. Twenty-one male subjects were divided into four groups and tested initially on various physiological

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[8]J. V. G. A. Durnin, J. M. Brockway, and H. W. Whitcher, "Effects of a Short Period of Training of Varying Severity on Some Measurements of Physical Fitness," Journal of Applied Physiology, 15:161-165, January, 1960.

[9]Jay H. Jackson, Brian J. Sharkey, and L. Pat Johnson, "Cardio-respiratory Adaptions to Training at Specified Frequencies," Research Quarterly, 39:295-300, May, 1968.

tests related to cardiovascular fitness. The study consisted of two phases, Phase I was a five-week conditioning period and Phase II was five weeks of post-conditioning. During the conditioning period all subjects rode the bicycle ergometer five days per week for thirty minutes a session. The work load was controlled by the heart rate as the subjects rode throughout the session at a rate equal to 80 per cent of their maximum heart rate. Measurements of all physiological parameters included in the study were taken following the conditioning phase. In the post-conditioning phase the four groups of subjects trained at different frequencies in order to determine which frequency would best maintain a cardiovascular condition. Group I trained one day per week, Group II trained two days per week, Group III trained three days per week, and Group IV trained four days per week. The intensity and duration of exercise was the same in the post-conditioning phase as it was in the conditioning phase. Brynteson reports that a five-week physical conditioning program on a bicycle ergometer at an exercise intensity of 80 per cent of the subject's maximum heart rate is sufficient to improve cardiovascular fitness. It was also reported that at least three days per week of exercising at 80 per cent of the subject's maximum heart rate is necessary to maintain cardiovascular fitness.[10]

Kirby utilized one hundred and forty male students to investigate the effects of various exercise programs involving different amounts of

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[10] P. H. Brynteson, "The Effects of Training Frequencies on the Retention of Cardiovascular Fitness" (unpublished Doctor's dissertation, Springfield College, Springfield, Massachusetts, 1969), pp. 1-155.

exercise on the development of certain components of physical fitness. His subjects were pre-tested for performance on the Harvard Step Test and then trained three times per week for six weeks. All five groups attended and participated in the basic instruction physical education class. Each group was assigned additional selected exercises for the study. Group I performed one isometric exercise; Group II, one isometric exercise and running in place; Group III, one isometric, running in place, and a vertical jump; Group IV, one isometric, running in place, vertical jump, and push-ups; and Group V participated in a class devoted entirely to exercising. The groups were post-tested upon completion of the investigation and the following conclusions obtained. Within the limits of the investigation it appears that cardiovascular efficiency can be improved significantly by engaging in a few activities vigorously in addition to the basic instruction classes. Kirby also states that it may be the intensity of effort applied while exercising that is the major factor in conditioning rather than the time or number of exercises involved in the program.[11]

Harper tested the effect of interval, recreational, calisthenics, and marching training programs on fitness in man. Twenty-five male undergraduates from Ohio State University served as the subjects. The subjects were first pre-tested for maximal oxygen uptake, performance on the Harvard Step Test and the Army Physical Fitness Test. Three equated

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[11]Ronald F. Kirby, "The Effects of Various Exercise Programs Involving Different Amounts of Exercise on the Development of Certain Components of Physical Fitness" (unpublished Doctor's dissertation, Louisiana State University, Baton Rouge, 1966), pp. 1-112.

groups were formed on the basis of the initial maximum oxygen uptake for training. The subjects trained each day for seven weeks. Group I used an interval running training program; Group II, the army program consisting of calisthenics and marching; and Group III participated in recreational activities such as golf, swimming, etc. After seven weeks the subjects were tested again on the same tests with the following results. The interval running program significantly improved maximum oxygen uptake, whereas the other programs did not. The interval running and army groups significantly improved on the Army Physical Fitness Test.[12]

Westering investigated the effects of various programs of physical conditioning on selected measures of physical performance. One hundred and forty male subjects were administered a battery of ten physical performance tests prior to the training program. The subjects were then divided into four groups within each basic instruction class. Group I performed a four-minute isometric training period in addition to class; Group II, a fifteen-minute training period of calisthenics in addition to class; Group III, a seven-minute training period consisting of intensive exercises plus class; and Group IV, class plus a thirteen-minute circuit training program. At the end of the eight weeks of training the subjects were again given the physical performance test battery. The results show that the isometric group failed to improve significantly in any of the

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[12]Donald DeWayne Harper, "Effect of Interval, Recreational, Calisthenics, and Marching Training Programs on Fitness in Man" (unpublished Doctor's dissertation, Ohio State University, Columbus, 1966), pp. 1-93.

tests, whereas the calisthenic group improved significantly in three performance tests. Both the intensive and circuit training groups improved significantly in seven of the ten tests. Westering concludes that a higher degree of physical performance was developed through the use of the intensive or circuit training programs as compared to the conventional calisthenic program.[13]

Milton studied the effects of three programs of long-distance running and an isometric exercise program on the development of cardio-vascular efficiency. The subjects were four hundred and sixty-three males from Kansas State Teachers College. All of the subjects were pre-tested for cardiovascular fitness levels by means of the Harvard Step Test and then assigned to one of four groups. Group I was engaged in a program of long-distance running for ten minutes per session. Group II and III followed the same program as Group I except that they ran for twenty and thirty minutes per session, respectively. Group IV trained on an isometric program. All groups trained four days per week for seven weeks after which the Harvard Step Test was again administered. Milton found that all four programs produced significant gains in cardiovascular efficiency. There was no significant difference among the three running programs, but they were all found to be superior to the isometric program in improving cardiovascular efficiency. Milton

[13]Forrest Edward Westering, "The Effects of Various Programs of Physical Conditioning on Selected Measures of Physical Performance" (unpublished Doctor's dissertation, Colorado State College, Greeley, 1966), pp. 1-117.

concluded that, generally, distance running will bring about more improvement than isometrics in cardiovascular efficiency.[14]

Roskamm conducted a study using eighty soldiers to investigate the optimum patterns of exercise for healthy adults. Initial fitness levels for each subject were established by a steady state test on the bicycle ergometer. Four equated groups were established and put into a training period of four weeks. The training programs consisted of one-half hour of work on the bicycle ergometer daily. Group I pedalled at a rate which equaled 70 per cent of their maximum heart rate for the full thirty minutes. Group II worked at a rate which was 50 per cent higher than Group I for one minute and then dropped to a rate which was 50 per cent lower for one minute. These subjects were simulating interval training. Group III was essentially the same as Group II except that their intervals were two and one-half minutes in duration. Group IV served as the control. All groups were post-tested upon completion of the four-week training period. Roskamm found that training by means of uninterrupted work was more effective in decreasing the resting heart rate. The author also concluded that interval training was the most effective in improving maximum working capacity.[15]

Naughton investigated the cardiorespiratory endurance before and after regular physical activity. He used a forty-eight year old subject

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[14]George Cohle Milton, "The Effects of Three Programs of Long Distance Running and an Isometric Exercise Program on the Development of Cardiovascular Efficiency" (unpublished Doctor's dissertation, Louisiana State University, Baton Rouge, 1966), pp. 1-95.

[15]H. Roskamm, "Optimum Patterns of Exercise for Healthy Adults," Canadian Medical Association Journal, 96:895-899, March, 1967.

and trained him every day for two years. Initially the subject was tested on the treadmill to gain a starting point for physical fitness. The training program consisted of twenty minutes of jogging every day. The subject began by jogging at a pace of two and one-half minutes per quarter mile and, as he improved, he gradually worked up to the point where he was jogging three to four miles comfortably in thirty-two minutes. The treadmill evaluations were conducted every six months during the training period for the duration of two years. Naughton found that after two years of increased working the aerobic capacity increased from 34.6 to 46.2 ml./kg. Also, after the regular exercise program was initiated, at each subsequent evaluation substantially lower systolic blood pressure levels were recorded both at rest and during exercise. Additional lowering of the systolic pressure occurred when the activity program became more strenuous. The diastolic blood pressure after two years did not change significantly for the resting value; however, the diastolic blood pressure level during comparable bouts of treadmill work showed a decrease.[16]

Churdar conducted a study of the effect of four different frequencies of a specific exercise program on physical fitness. Thirty-three males from Florida State University were randomly placed into five groups. Initial levels of fitness were computed by use of a modified step-up test. The training program used was "level C" of the Royal Canadian Air Force 5BX plan. The subjects trained for twelve weeks at

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[16] John Naughton, "Cardiovascular Endurance Before and After Regular Physical Activity," Minnesota Medicine, 51:619-623, May, 1968.

different frequencies. Group I participated once per week; Group II, twice per week; Group III, three times per week; Group IV, six times per week; and Group V was the control and participated in no exercise at all. Upon completion of the twelve-week program a post-test was administered. The results showed a significant improvement in the physical fitness of the groups training two, three, and six days per week. They also showed that participating six days per week was significantly better than one and almost better than two.[17]

Doherty conducted a study to determine the effects of ten-minute programs of stressful exercise on the endurance of adolescent boys. He utilized one hundred and twenty-five boys in attendance at a music camp at Interlochen, Michigan. His subjects were randomly divided into five groups, each group then taking four pre-tests consisting of the Harvard Step Test, two applications of a bicycle ergometer test, and a six hundred yard run. Doherty's subjects underwent six weeks of training on different programs. Group I was on a continuous cycling program, Group II maintained an interval cycling program, Group III used continuous running, and Group IV served as the control. Following this training regime, the subjects were post-tested. Doherty found that the mean endurance fitness level of the four groups that trained improved. Neither the continuous cycling nor the interval cycling appeared to be superior

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[17]John B. Churdar, "A Study of the Effect of Four Different Frequencies of a Specific Exercise Program on Physical Fitness" (unpublished Doctor's dissertation, Florida State University, Tallahassee, 1967), pp. 1-102.

to the other, and none of the programs appeared to increase endurance beyond the regular camp program.[18]

Bakar compared rope skipping and jogging as methods of improving the cardiovascular efficiency of college men. Ninety-two men were randomly placed in two groups. The Harvard Step Test was administered before training to establish a physical fitness level for the subjects. The training period lasted six weeks during which time the subjects trained five days per week. Group I engaged in rope skipping for 10 minutes per day. They began at a frequency of one hundred and twenty-five turns per minute and, as they improved, gradually worked up to one hundred and seventy turns per minute. Group II jogged thirty minutes per day beginning at a pace of three minutes per quarter mile or a twelve-minute mile pace. They were allowed to step up the pace as their condition improved but not to exceed two minutes per quarter mile or an eight-minute mile pace. Upon completion of the six weeks training period, the Harvard Step Test was again administered. It was found that a daily program of ten minutes of rope skipping significantly improved cardiovascular efficiency as did a thirty-minute program of jogging. For the intensities specified, the author recommends ten minutes of rope skipping per day as compared to thirty minutes of jogging per day for developing cardiovascular efficiency.[19]

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[18]Lynn Mason Doherty, "The Effects of Ten Minute Porgrams of Stressful Exercise on the Endurance of Adolescent Boys" (unpublished Doctor's dissertation, Boston University School of Education, 1967), pp. 1-113.

[19]John A. Bakar, "Comparison of Rope Skipping and Jogging as Methods of Improving Cardiovascular Efficiency of College Men," Research Quarterly, 39:240-243, May, 1968.

Shephard, in a commentary appearing in the "Canadian Medical Association Journal," states that he is currently involved in research studying the influence of intensity, duration, and frequency of treadmill exercise upon aerobic capacity. At the outset of the study the mean aerobic capacity of Shephard's twenty-five subjects was 35.6 ml. O_2/Kg./min. The training program involves training at one of three intensities, either thirty-five per cent of the subject's maximum heart rate, sixty-five per cent, or ninety per cent. The subjects train at durations of five, ten or twenty minutes and frequencies of once, twice or three times per week. Up to this point the study shows that two variables influence the training response. One is the intensity of exercise and the other is the initial fitness level of the subject. Shephard suggests that the threshold of exercise for sedentary persons can be lower than the recommended one hundred thirty-five to one hundred and fifty beats per minute and still produce a training response. He states that this is due to the fact that pulse rates greater than one hundred twenty beats per minute are foreign to most sedentary individuals.[20]

Summary

The literature relating to improvement of general cardiovascular conditioning exhibits wide variation in the scope of the variables measured, subjects used, conditions present, treatments administered, criteria, and the results and conclusions made. However, most of the

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[20] R. J. Shephard, "Commentary," Canadian Medical Association Journal, 96:899, March, 1967.

literature reviewed reveals that general cardiovascular conditioning is directly related to the intensity of exercise. Some of the authors who support this idea are Kirby,[21] McNair,[22] Brynteson,[23] and Shephard.[24] General cardiovascular conditioning is best summed up by Kirby when he stated:

> ...it is the intensity of effort applied while exercising, even if it is only a single exercise of but a few seconds duration, that is the major factor in conditioning rather than time spent or number of repetitions and/or number of exercises involved in the exercise program.[25]

Literature Relating to Cholesterol, Body Weight, and Percentage Body Fat

Garrett conducted a study of the effects of a strenuous physical conditioning program on coronary risk factors in men. Thirteen subjects were selected based on levels of cholesterol, blood pressure, and obesity. The study was divided into three phases, a pre-training phase during which time baseline measurements were obtained for the variables to be tested, the training phase, and a post-training phase. The phases were four, six, and four weeks duration respectively. Measurements were repeated at the end of the training phase and again at the end of the post-training phase. Garrett reports that the experimental groups mean body weight went down significantly as did the levels of serum

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[21]Kirby, loc. cit.

[22]McNair, loc. cit.

[23]Brynteson, loc. cit.

[24]Shephard, loc. cit.

[25]Kirby, op. cit., p. 68.

cholesterol. Physical fitness levels increased significantly after the training phase. Diastolic blood pressure levels were significantly reduced at the end of the training phase but these levels returned to pre-training levels after the post-training phase. Systolic blood pressure levels were not significantly affected by the training phase.[26]

Terraslinna studied the effect of exercise on selected serum lipids and their relationships to certain variables of body structure and function. The purpose of the study was to discriminate between fit and unfit subjects. Seventeen different physiological variables were measured under various conditions. The conditions were at rest, after a period of submaximal activity, after a period of maximal activity, and after a recovery period. It was concluded that serum cholesterol had discriminating powers as to "fit" and "unfit" groups.[27]

Pollock randomly placed nineteen men into two groups for the purpose of investigating the effect of frequency of training on working capacity, body composition, and circulo-respiratory measures. The subjects trained thirty minutes per day for twenty weeks. Group I trained two times per week whereas Group II trained four times per week. The training program consisted of continuous walking, jogging, or running. Pre-tests were administered for the various parameters measured

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[26]Hubert Leon Garrett, "The Effects of a Strenuous Physical Conditioning Program on Coronary Risk Factors in Men" (unpublished Doctor's dissertation, George Peabody College, Nashville, Tennessee, 1965), pp. 1-215.

[27]Peutti Terraslinna, "Effect of Exercise on Selected Serum Lipids and their Relationships to Certain Variables of Body Structure and Function" (unpublished Doctor's dissertation, Purdue University, 1966), pp. 1-140.

as well as post-tests. The results showed both groups improved significantly in maximum V_{O_2} and significantly decreased the values for resting, exercise, and recovery heart rates. The body composition for Group I stayed the same but Group II significantly improved in total body weight and per cent fat. The analysis between the groups showed that improvements were manifested in accordance with frequency of participation.[28]

Campbell investigated the influences of several physical activities on serum cholesterol concentration in college freshmen. One hundred and thirty-three subjects were randomly assigned to the following activities including cross-country running, weight training, tumbling, wrestling, tennis, golf, and a control. Serum cholesterol levels were measured before and after training by a method prescribed by Abell. The mean initial serum cholesterol level for all the groups was 177.4 mg./100 ml. of blood, with the mean average change for all groups being a -1.94 mg./100 ml. of blood. However, it must be noted that these are means and that the individual groups did vary in amount of change. Campbell found that cross-country running produced a significant decrease in serum cholesterol when compared with all other activities except tennis. It was concluded that cross-country running and tennis are phasic activities and produced decreases in serum cholesterol proportional to their relative intensities, whereas the more static activities

[28]Michael Lee Pollock, "Effects of Frequency of Training on Working Capacity, Body Composition, and Circulo-Respiratory Measures" (unpublished Doctor's dissertation, University of Illinois, Urbana, 1967), pp. 1-165.

of wrestling, weight training, and tumbling produced little or no detectable change.[29]

Campbell studied the influence of diet and physical activity on blood serum cholesterol levels of young men. Volunteer subjects were tested by Behnke's method to determine whether the subject was classified as lean, muscular, or obese. When all of the subjects had been classified and weighed, they were randomly placed into active and inactive groups. Following this, the subjects were pre-tested for cholesterol levels. The initial mean serum cholesterol level for the active groups was 193.34 mg./100 ml. of blood, and the same level for the inactive groups was 195.15 mg./100 ml. of blood. The active group ran on a treadmill three times per week for ten weeks, whereas the inactive did nothing. Post-tests for cholesterol levels and body weight were given following the ten-week training period. The final mean serum cholesterol level for the active groups was 187.61 mg./100 ml. of blood and the same level for the inactive groups was 193.30 mg./100 ml. of blood. The active groups showed a mean change in serum cholesterol resulting in a decrease of 5.73 mg./100 ml. of blood, whereas the inactive group's mean change was a decrease of 1.85 mg./100 ml. of blood. There was a significant difference between active and inactive subjects and between groups in the levels of blood serum cholesterol, whereas the mean changes in body weight were not significant. The greatest mean reduction in serum

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[29]Donald E. Campbell, "Influence of Several Physical Activities on Serum Cholesterol Concentrations in Young Men," Journal of Lipid Research, 6:478-480, 1965.

cholesterol and body weight occurred in the obese active group.[30]

Montoye, et al. studied the relationship between serum cholesterol and body fatness. Tests were run on the majority of the population of Tecumseh, Michigan. Correlations were determined for all individuals taking the tests on serum cholesterol levels and body fatness. Measurements were taken using a skin-fold caliper and Abell's method for measuring cholesterol. A low (.43), but statistically significant, relationship was found between serum cholesterol levels and body fatness.[31]

Goode and others studied the effects of exercise and a cholesterol-free diet on human serum lipids. Six male subjects whose ages ranged from twenty-five to forty-six were maintained on a diet free of all animal fats for a period of fifty-four days. For the first three weeks the subjects underwent normal activities and basal measurements for cholesterol were attained. After three weeks, three of the subjects began running on a treadmill for twenty-five minutes per day for fourteen consecutive days while the other three subjects acted as controls. There was a five-day rest period following this and then the procedure was reversed for another fourteen-day period. In the first three weeks of the restricted diet all subjects showed substantial reductions in serum cholesterol. Then as the experiment continued, the cholesterol levels

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[30]D. E. Campbell, "Influence of Diet and Physical Activity on Blood Serum Cholesterol of Young Men," American Journal of Clinical Nutrition, 18:79-85, February, 1966.

[31]Henry J. Montoye, Frederick H. Epstein, and Marcus O. Kjelsberg, "Relationship Between Serum Cholesterol and Body Fatness," American Journal of Clinical Nutrition, 18:397-406, June, 1966.

tended to increase in both groups. Exercise can initiate a trasient increase of serum cholesterol in subjects on an unrestricted diet. This is thought to be due to increased fat mobilization for energy production, which could in turn be a first step toward lowering of body stores of cholesterol.[32]

Montoye and colleagues used thirty-one faculty members at Michigan State University to investigate the effects of exercise on blood cholesterol. The subjects were pre-tested for initial levels of cholesterol and then randomly placed into two groups. Group I was the exercise group. Their initial mean serum cholesterol level was 189.5 mg./100 ml. of blood and their mean age was forty-three years. Group II served as the control. Their initial mean serum cholesterol level was 194.6 mg./100 ml. of blood and their mean age was forty-one years. Five subjects whose initial mean serum cholesterol level was 239.8 mg./100 ml. of blood were judged to be initially high level subjects and were treated separately. Three of these men exercised and the other two were controls. The exercise group underwent three months of supervised exercises, whereas the control remained inactive. Upon completion of the training period the subjects were post-tested. The exercise group's final mean serum cholesterol level was 187.1 mg./100 ml. of blood and the same level for the control group was 196.6 mg./100 ml. of blood. The initially high-level subjects' final mean was 212.4 mg./100 ml. of blood. These subjects also lost the most weight during the study. The

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[32] R. C. Goode, J. B. Firstbrook, and R. J. Shephard, "Effects of Exercise and a Cholesterol-Free Diet on Human Serum Lipids," Canadian Journal of Physiology and Pharmacology, 44:575-580, July, 1966.

results indicated that a change in total serum cholesterol generally accompanied a change in body weight. Exercise was therefore effective indirectly by decreasing the body weight.[33]

Golding investigated the effects of physical training upon total serum cholesterol levels. Eight subjects from the physical education instructional staff at the University of Illinois participated in twenty-five weeks of severe endurance activities. Cholesterol levels were measured before and after the endurance training period. There were two groups; Group I was experimental and Group II was the control. The initial mean serum cholesterol level of the experimental group was 342 mg./100 ml. of blood, whereas the same value for the control group was 272.5 mg./100 ml. of blood. The final mean values for these two groups were 252 mg./100 ml. of blood and 278.75 mg./100 ml. of blood respectively. The results of this study showed that the specific gravity values of the subjects increased as the cholesterol levels were reduced. It appeared as though cholesterol behaved much like fat as far as the effect of exercise was concerned. The four experimental subjects lowered their total serum cholesterol levels in the same relationship as the total fat measures. In these subjects, fat reduced as serum cholesterol reduced.[34]

Rochelle utilized twelve adults, six for an experimental group and

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[33]Henry J. Montoye, et. al., "The Effects of Exercise on Blood Cholesterol in Middle-Aged Men," American Journal of Clinical Nutrition, 7:139-145, March-April, 1959.

[34]Lawrence A. Golding, "Effects of Physical Training upon Total Serum Cholesterol Levels," Research Quarterly, 32:499-506, December, 1961.

six for a control, in studying the changes in blood cholesterol during a physical training program. The training program consisted of a daily two-mile run for time. The training period consisted of three phases: a two-week pre-training period, then a five-week conditioning period, and finally an eight-week post-training phase. Cholesterol levels were measured before the training began and during all phases of training. The control groups' pre-training mean cholesterol level was 202.8 mg./100 ml. of blood and their post-training mean level was 179.5 mg./100 ml. of blood. On the other hand, the control group's pre-training mean cholesterol level was 187 mg./100 ml. of blood and their post-training level was 188 mg./100 ml. of blood. Rochelle reported that physical training produced a significant decrease in plasma cholesterol. There was a temporary rise in cholesterol during activity probably due to increased fat mobilization. The cholesterol level of each of the experimentals returned to pre-training levels within four to six weeks after training was stopped.[35]

Campbell studied the effect of controlled running on serum cholesterol of young adult college men of varying morphological constitutions. One hundred and thirty students were measured by Behnke's method in order to classify them as obese, muscular, or lean. Within each classification there were two groups, active and inactive. The training period was ten weeks long with the active subjects exercising on the treadmill three times per week. Cholesterol was measured before and after the

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[35]R. H. Rochelle, "Blood Plasma Cholesterol Changes during a Physical Training Program," Research Quarterly, 32:538-550, December, 1961.

training period. The initial mean of all the active groups was 189 mg./100 ml. of blood. The same value for all of the inactive groups was 196 mg./100 ml. of blood. Each training session consisted of six five-minute bouts of exericse on the treadmill with a five-minute rest between each. Upon completion of the training period the active group's mean level was found to be 184 mg./100 ml. of blood, whereas the same level for the inactive groups was 200 mg./100 ml. of blood. Campbell reports that the obese active group was the only group to show a significant change in serum cholesterol.[36]

Anderson studied the effect of a physical conditioning program on one hundred unfit, overweight, subjects from Pennsylvania State University. The subjects were divided into an experimental and control group and measured for total body density and percentage fat. The training period was nine weeks in duration during which time the experimental group exercised three times per week. When the training period was completed the subjects were again measured for total body weight and percentage of fat. Anderson noted that a physical conditioning program consisting of vigorous physical exercise three times per week will decrease body fat causing an increase in body density.[37]

Campbell used a large group of healthy male college students to

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[36]Donald E. Campbell, "Effect of Controlled Running on Serum Cholesterol of Young Adult Males of Varying Morphological Constitutions," Research Quarterly, 39:47-53, March, 1968.

[37]Richard E. Anderson, "The Effect of a Physical Conditioning Program on Body Fat and Body Density" (unpublished Master's thesis, Pennsylvania State University, University Park, 1965), pp. 1-68.

study cholesterol concentrations during physical training and subsequent detraining. The subjects were initially classified according to morphological configuration and separated into three groups: obese, muscular, and slim. The two treatments were ten weeks of conditioning on a treadmill three times per week and ten weeks of de-conditioning with no activity. Blood samples for measuring cholesterol concentrations were taken before training, after Treatment I, and after Treatment II. Obese subjects had the highest initial levels and showed the greatest decrease during activity and the greatest increase once activity ceased. The results suggest that when attempts are made to appraise the influence of physical activity on serum cholesterol concentrations, the body configurations of the subjects must be considered.[38]

Hoffman and others investigated the effects of an exercise program on the plasma lipids of some Air Force Officers. The officers were surveyed to find out the amount of physical activity they engaged in regularly and then two groups were formed. Group I consisted of those officers who exhibited a high level of fitness according to the Royal Canadian Air Force 5BX plan. Group II was made up of the remaining officers. The subjects then continued their own fitness plans throughout the year and were measured for cholesterol at various points in the year. The results indicated that the highest exercise group demonstrated lower

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[38]Donald E. Campbell, Treve B. Lumsden, "Serum Cholesterol Concentrations during Physical Training and during Subsequent Detraining," American Journal of Medical Science, 253:155-162, February, 1967.

levels of total cholesterol.[39]

Summary

The effect of training on cholesterol, body weight, and body fat percentage depend almost entirely upon two variables. These variables are: (1) the intensity of exercise, and (2) the initial values for the parameters being measured. This idea or the equivalent of it is endorsed by Pollock,[40] Campbell,[41,42,43] Goode,[44] Montoye,[45] and others. There seems to be agreement that as cholesterol levels went down with training, so did body weight and percentage fat. The cholesterol and body fat percentages were greatest among subjects who were overweight and out of shape. Among subjects whose initial cholesterol levels were low, very little, if any, reduction in cholesterol was evidenced as a result of the training programs.

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[39]Brig. Gen. Archie A. Hoffman, Col. Frank A. Goss, and William R. Nelson, "Effects of an Exercise Program on Plasma Lipids of Senior Air Force Officers," American Journal of Cardiology, 20:516-524, October, 1967.

[40]Pollock, loc. cit.

[41]Campbell, American Journal of Clinical Nutrition.

[41]Campbell, Journal of Lipid Research.

[42]Campbell, American Journal of Medical Science.

[43]Goode, loc. cit.

[44]Montoye, loc. cit.

CHAPTER III

METHODS AND PROCEDURES

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METHODS AND PROCEDURES

Organization of the Study

The study was carried out over a fourteen-week period beginning on February 9, 1970, and ending on May 8, 1970. This fourteen-week period was divided into two five-week training periods, separated by one week of testing and one week of Easter vacation. Data from the selected physiological parameters were collected prior to the start of the training program (Test I), after five weeks of conditioning (Test II), and upon completion of the ten-week conditioning program (Test III). The parameters measured were cholesterol, body weight, and percentage body fat.

The experimental design of the study was a two-by-three factorial design. The study had two variables, intensity of the training programs and the duration of each training session. The subjects were trained at an intensity of either 70 per cent of their maximal heart rate or 80 per cent of their maximal heart rate. The duration of each training session was either ten, twenty, or thirty minutes. A graphical diagram of the study is presented in Table I.

TABLE I

GRAPHIC DIAGRAM OF THE STUDY DESIGN

		Intensity of Training	
		70%	80%
Duration of the Training Session	10 min.	Group I	Group II
	20 min.	Group III	Group IV
	30 min.	Group V	Group VI

All subjects trained three times per week during both of the five-week training periods on one of three bicycle ergometers in the Human Performance Laboratory at South Dakota State University.

Source of the Data

At the beginning of the study, sixty male volunteers from the freshman basic instruction classes at South Dakota State University were randomly selected from a larger population of volunteers. The sixty subjects were randomly assigned to the six groups. The groups were equated by use of the rank order method on the basis of data obtained from a pretest of maximal oxygen uptake. The six groups of subjects trained at the specific intensity and duration assigned to their group according to Table I. Due to reasons beyond the control of the investigator, five subjects had to be dropped from the study and thus the final sample consisted of fifty-five subjects.

Administration of the Treatment

The treatment consisted of riding a bicycle ergometer three times per week for ten weeks. Training was carried out at a rate prescribed for each group in Table I. Groups I and II trained for ten minutes per session at 70 and 80 per cent of their maximal heart rate respectively. Groups III and IV trained for twenty minutes per session at 70 and 80 per cent of their maximal heart rates and Groups V and VI trained for thirty minutes per session at 70 and 80 per cent of their maximal heart rates respectively. Daily training sessions were arranged by the investigator in cooperation with the subject's university academic schedule.

Collection of the Data

Data were collected before the training began, after five weeks of training, and upon conclusion of the ten-week training program. Data were collected on the parameters of cholesterol, body weight, and percentage body fat. The sections that follow explain the procedure in the measurement of the selected parameters.

Cholesterol. Cholesterol was measured according to the procedure described by Ferro and Ham.[46] This procedure was selected because accurate results can be obtained from a very small blood sample (2.0 cc.). The investigator's pilot study utilized test-retest reliability of duplicate samples and revealed a correlation of .99. The following

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[46]P. V. Ferro, and Annabelle Ham, "Cholesterol Measurement," Technical Bulletin of the Registry of Medical Technologists, 30:71, May, 1960.

method was used:

1. Prior to testing for cholesterol from blood samples, a stock solution of color developing reagent was made up. To accomplish this, two parts of glacial acetic acid were mixed with three parts of acetic anhydride. To every ten cubic centimeters of the above solution, one cubic centimeter of concentrated sulfuric acid was added. This solution was the color developing reagent and was kept in supply in the laboratory.
2. The investigator collected the blood samples from a finger on the left hand using a lancet after the hand had been warmed in water for five minutes. The sample was collected in a capillary tube and one end was capped. The blood samples were then allowed to stand and clot throughout the day.
3. The investigator analyzed the samples for cholesterol during the evening. The first step involved centrifuging the samples to separate the serum from the blood cells.
4. One-tenth of a cubic centimeter of serum was then mixed with an equal volume of water. Six cubic centimeters of color developing reagent were then mixed into the serum and water solution. It was then quickly put into a test tube for analysis in the colorimeter.
5. Immediately the sample was placed in the colorimeter and the maximum optical density was determined. Previous to testing the samples, the maximum optical density of a standard serum was determined. The amount of cholesterol in the sample was

derived from the following equation:

$$\frac{\text{(Maximum Optical Density-Unknown)}}{\text{(Maximum Optical Density-Standard)}} \times 357 = \text{Chol. \%}$$

Body weight. The subjects were weighed on a standard platform balance beam scale and their weights recorded to the nearest pound.

Percentage body fat. Percentage body fat was measured according to a procedure explained by Wilmore and Behnke.[47] The body density of 133 male college students was determined by the underwater weighing technique. The authors then obtained different anthropometric measurements from fifty-four sites on the body. Zero order correlations showed substantial relationships between the measurements, body density, and lean body weight. The total anthropometric data were then run through a stepwise multiple linear-regression process to predict body density and lean body weight. Twelve regression equations were developed, six for each parameter. For the present study, the investigator adopted that equation which exhibited a combination of the highest multiple R (.876) and the lowest standard error of estimate (.0064).

$$\text{Body Density} = 1.05721 - 0.00052\,V_5 + 0.00168\,V_{13} + 0.00114\,V_{23} + 0.00048\,V_{25} - 0.00145\,V_{27}$$

V_5 = A horizontal skinfold measured two inches adjacent to the umbilicus using a Lange skinfold caliper with a caliper pressure of 10 g./mm^2.

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[47] Jack H. Wilmore and Albert R. Behnke, "An Anthropometric Estimation of Body Density and Lean Body Weight in Young Men," Journal of Applied Physiology, 27:25-31, July, 1969.

V_{13} = A bi-iliac diameter in centimeters measured with a broad blade enthropometer. (Measured as the distance between the most lateral projections of the iliac crests.)

V_{23} = Neck circumference. (Measured just inferior to the larynx using a centimeter tape.)

V_{25} = Chest circumference. (Measured on the nipple line at mid-tidal volume with a centimeter tape.)

V_{27} = Abdominal circumference. (Measured laterally, at the level of the iliac crests, and anteriorly, at the umbilicus using a centimeter tape.)

At least two independent anthropometric measurements were taken for each subject on the five sites. If the measurements were not exactly the same, a third measurement was taken and the mean of the three measurements was accepted as the representative value. In converting body density to percentage body fat, the authors used the following equation.[48]

Percentage body fat = (4.950/D - 4.500) 100

Procedure for the Collection of Data

The collection of the data for this study was completed during three one-week testing periods. There was a testing period before the study began, after the first five-week training period, and following completion of the ten weeks of training. The three testing periods were

[48]Wilmore, loc. cit.

identical to each other in procedure. The investigator devised a schedule for testing to accomodate each subject into a specific test time during each day of the testing period. The following section is for the purpose of explaining the testing procedures used during a typical test day.

1. The subjects reported to the Human Performance Laboratory dressed in T-shirts, gym shorts, and tennis shoes. Upon arriving in the lab, the subjects were instructed completely on the proceedings for all tests to be completed during their test period. This was done to avoid any confusion on the part of the subjects and to promote a smooth working procedure for testing the parameters of the study.
2. The subject was then asked to remove his T-shirt and tennis shoes and stand on a standard balance beam scale so that his weight could be recorded to the nearest pound.
3. The investigator then collected data from the anthropometric sites on the subject's body for the purpose of determining percentage body fat.
4. The subject then held his left hand in a basin of warm water in preparation for a skin puncture and collection of a small blood sample. The blood sample was then taken and the test day was completed.

CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS

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ANALYSIS AND DISCUSSION OF RESULTS

Organization of the Data for Analysis

The data obtained from the study were organized into a two-by-three factorial design for statistical analysis. The fifty-five subjects were divided among six groups and the groups were initially equated on the basis of a pre-test of maximal oxygen uptake.[49] There were two variables investigated in the study, intensity and duration of the training program. The two variations of the intensity variable were 70% and 80% of the maximal heart rate and the three variations of the duration variable were ten, twenty, and thirty minutes. Observation was conducted on the parameters of cholesterol, percentage body fat and body weight. Data were collected during a pre-test (Test I), after five weeks of training (Test II), and upon completion of the ten weeks of training (Test III). The group means for the three parameters appear in Table II. The raw data for the subjects appear in Appendices A-C.

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[49] J. A. Swisher, "The Effects of Selected Training Intensities and Durations on Improvement and Maintenance of Cardiorespiratory Fitness," (unpublished Master's thesis, South Dakota State University, Brookings, 1970) pp. 1-90.

TABLE II

GROUP MEANS FOR THE SELECTED PARAMETERS ON THE THREE TESTS

Parameter	Group	Test I	Test II	Test III
Cholesterol (mg./100 ml.)	I	177.22	192.56	193.33
	II	173.60	189.00	193.50
	III	190.71	215.86	203.86
	IV	166.80	181.40	177.90
	V	167.60	183.50	189.80
	VI	177.78	183.33	201.44
Total Mean		175.62	190.94	193.31
Percentage Body Fat (%)	I	14.33	15.22	15.44
	II	16.40	16.60	16.90
	III	15.14	16.43	17.29
	IV	18.60	19.30	18.70
	V	15.00	14.90	15.60
	VI	15.78	16.44	16.78
Total Mean		15.88	16.48	16.79
Body Weight (lbs.)	I	154.00	155.44	155.66
	II	155.20	156.00	156.40
	III	162.00	163.29	162.71
	IV	176.70	176.80	175.20
	V	147.70	149.10	148.40
	VI	164.55	164.67	166.56
Total Mean		160.03	160.88	160.82

The Least Squares Analysis of Variance method was used to conduct a statistical analysis of the data.[50] F ratios were computed to determine whether or not there was statistical significance among the groups

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[50]Robert G. D. Steel and James H. Torrie, Principles and Procedures of Statistics, (New York: McGraw-Hill Book Company, Inc., 1960), pp. 252-276.

for intensity, duration, or the interaction between the two variables. The .05 level of confidence was accepted as the minimum level necessary for an F ratio to be considered significant. If an F ratio was found to be significant, then a *t* ratio was computed to determine where the significance occurred. If an F ratio was not significant, the combined mean change of the entire six groups was analyzed. Confidence limits were placed on the combined mean change to determine if the change differed from zero. If the limits at the .05 level of confidence did not overlap zero, then the combined mean change was considered significant.

Analysis of the Data

Table III shows the Least Squares Analysis of Variance for the selected parameters from Test I to Test II. None of the parameters analyzed were significant.

TABLE III

ANALYSIS OF VARIANCE FOR THE SELECTED PARAMETERS FROM TEST I TO TEST II

Parameters	Sources of Variance	df	SS	MS	F*
Cholesterol	Total	55	571002.0000		
	MU	1	542770.2900	542770.2900	1227.482
	Intensity	1	658.7751	658.7751	1.490
	Time	2	7.6215	3.8107	.009
	Intensity x Time	2	1193.2962	596.6481	1.349
	Error	49	21666.9100	442.1818	
Percent Fat	Total	55	1251.0000		
	MU	1	1148.7947	1148.7947	593.051
	Intensity	1	1.8456	1.8456	.953
	Time	2	8.9599	4.4799	2.313
	Intensity x Time	2	.4203	.2101	.108
	Error	49	94.9175	1.9371	
Body Weight	Total	55	12440.0000		
	MU	1	11947.6970	11947.6970	1855.938
	Intensity	1	5.5372	5.5372	.860
	Time	2	1.7028	.8514	.132
	Intensity x Time	2	11.1219	5.5609	.864
	Error	49	315.4400	6.4376	

$^{*}F_{.05}(2/49) = 3.19$

$F_{.05}(1/49) = 4.04$

Table IV shows the Least Squares Analysis of Variance for the selected parameters from Test I to Test III. None of the parameters analyzed were significant.

TABLE IV

ANALYSIS OF VARIANCE FOR THE SELECTED PARAMETERS FROM TEST I TO TEST III

Parameter	Sources of Variance	df	SS	MS	F*
Cholesterol	Total	55	601608.0000		
	MU	1	571383.7700	571383.7700	1557.294
	Intensity	1	84.1117	84.1117	.229
	Time	2	524.3347	262.1673	.715
	Intensity x Time	2	542.0342	271.0171	.739
	Error	49	17978.5000	366.9082	
Percent Fat	Total	55	1476.0000		
	MU	1	1304.4098	1304.4098	376.983
	Intensity	1	6.3432	6.3432	1.833
	Time	2	11.1196	5.5598	1.607
	Intensity x Time	2	4.3859	2.1929	.634
	Error	49	169.5463	3.4601	
Body Weight	Total	55	12604.0000		
	MU	1	11851.3060	11851.3060	1072.164
	Intensity	1	8.5236	8.5236	.771
	Time	2	15.0110	7.5055	.679
	Intensity x Time	2	43.9464	21.9732	1.988
	Error	49	541.6280	11.0536	

$^*F_{.05}(2/49) = 3.19$

$F_{.05}(1/49) = 4.04$

Table V shows the mean changes of the combined groups for cholesterol, percentage body fat, and body weight from Test I to Test II and Test II to Test III. Cholesterol showed a mean increase of 15.14 mg./100 ml. of blood for the combined groups from Test I to Test II. It should be noted that an increase in cholesterol is not desirable. This increase was found to be significant beyond the .01 level of confidence. Percentage body fat showed a mean increase of .61% for the combined groups from Test I to Test II, which was significant at the .01 level of confidence. Also, a mean change of .86 pounds in body weight for the combined groups from Test I to Test II was found to be significant at the .05 level of confidence. During the period from Test II to Test III the parameters stabilized and no significant differences were found.

TABLE V

MEAN CHANGE OF THE COMBINED GROUPS FROM TEST I TO TEST II AND TEST II TO TEST III

Test Comparison	Parameter	Mean Change	SE_m	Confidence Limits .05	.01
I to II	Cholesterol	15.14	2.840	5.710	7.610*
	Percent Fat	.61	.189	.380	.507*
	Body Weight	.86	.342	.687*	.917
II to III	Cholesterol	2.36	3.750	7.540	---
	Percent Fat	.35	.209	.420	---
	Body Weight	.09	.459	.923	---

*Indicates the confidence limit at which significance occurred.

Discussion of Results

No significant differences were found among the groups for intensity, duration, or the interaction between the two variables. On the basis of the results, it was decided to analyze the combined mean changes in each parameter for the entire six groups. Confidence limits were placed on the combined mean change to determine if the change differed from zero. If the limits at the .05 level of confidence did not overlap zero, then the combined mean change was considered significant.

From Test I to Test II cholesterol changed from an initial combined groups' mean of 175 mg./100 ml. of blood to a mean level of 190 mg./100 ml. of blood. This increase of 15 mg./100 ml. of blood was found to be significant beyond the .01 level of confidence. Also increasing from Test I to Test II and revealing significance at the .01 level of confidence was percentage body fat. A change from a combined groups' initial mean of 15 per cent body fat to a mean of 16 per cent body fat after five weeks of training (Test II) was evidenced. The initial mean for the combined groups' body weight was 160 pounds. After five weeks of training (Test II) this mean changed to 161 pounds. The change of one pound was found to be significant at the .05 level of confidence.

The five-week training period from Test II to Test III produced no significant changes in the combined groups' means for the parameters of the study.

In discussing the results of this investigation, it should be noted that cholesterol, percentage body fat, and body weight react to exercise according to two important variables: (1) the intensity of exercise and (2) the initial values for the parameters being measured. For the parameters of this study, the higher the intensity of exercise and the higher the initial value of the parameter, the greater the change would be over a given training period. The related literature supports this principle. Campbell reports in three separate studies virtually no changes in cholesterol among training groups having initially low mean cholesterol levels. His low levels ranged from 177.4 to 193.34 mg./100 ml. of blood.[51,52,53]

On the other hand, some of the literature reviewed reveals much greater changes among those training groups which had initially high mean cholesterol levels.[54,55] The means as recorded in such studies ranged from 239.8 to 342 mg./100 ml. of blood. The study reported by Golding revealed a significant mean decrease in cholesterol from 342 to 252 mg./100 ml. of blood with conditioning.

Of particular interest are the studies reported by Goode[56] and Rochelle.[57] These authors indicate that slight increases in cholesterol

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[51]Donald E. Campbell, "Influence of Several Physical Activities on Serum Cholesterol Concentrations in Young Men," Journal of Lipid Research, 6:478-480, 1965.

[52]Donald E. Campbell, "Influence of Diet and Physical Activity on Blood Serum Cholesterol of Young Men," American Journal of Clinical Nutrition, 18:79-85, February, 1966.

[53]Donald E. Campbell, "Effect of Controlled Running on Serum Cholesterol of Young Adult Males of Varying Morphological Constitutions," Research Quarterly, 39:47-53, March, 1968.

[54]Lawrence A. Golding, "Effects of Physical Training upon Total Serum Cholesterol Levels," Research Quarterly, 32:499-506, December, 1961.

[55]Henry J. Montoye, et. al., "The Effects of Exercise on Blood Cholesterol in Middle-Aged Men," American Journal of Clinical Nutrition, 7:139-145, March-April, 1959.

[56]R. C. Goode, J. B. Firstbrook, and R. J. Shephard, "Effects of Exercise and a Cholesterol-Free Diet on Human Serum Lipids," Canadian Journal of Physiology and Pharmacology, 44:575-580, July, 1966.

[57]R. H. Rochelle, "Blood Plasma Cholesterol Changes during a Physical Training Program," Research Quarterly, 32:538-550, December, 1961.

may initially occur as the result of a training program. They state that the increases may be due to increased fat mobilization for energy production during activity or it might also be caused by an unrestricted diet among the subjects.

The above literature has implications for the present study as no restrictions were placed on the subjects' diet and the study revealed a significant increase in cholesterol, percentage body fat, and body weight for the combined groups over the first five weeks of the training program (Test I to Test II). The significant increases in the parameters of this study may have been caused by an increase of food intake. A moderate training program for the subjects may have caused this increase in food intake. Support for this implication is given by Cooper when he states that moderate exercise may increase the appetite; however, intense exercise for even short periods of time, will definitely decrease the appetite.[58] If moderate exercise can cause an increased appetite, then a caloric imbalance could have been set up among the subjects of this study. A greater intake than expenditure of calories could then be responsible for the significant increases that occurred for the combined groups' mean cholesterol, percentage body fat, and body weight over the first five weeks of the training program (Test I to Test II).

Additional support can be gained from a concurrent study on the

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[58]Kenneth H. Cooper, M.D., The New Aerobics, (New York: M. Evans and Co., 1970), p. 39.

same subjects reported by Swisher.[59] He reports that no significant increase occurred in the mean for maximal oxygen uptake of the combined groups over the first five weeks of the training program (Test I to Test II). Swisher indicated that one factor that could have affected the lack of change is the initially high mean (49.60 ml./kg./min.) of the subjects. The lack of significant change in the mean of the subjects' maximal oxygen uptake from Test I to Test II in combination with their initially high mean for maximal oxygen uptake would seem to indicate that the training program used in the present study was indeed only moderate in intensity and duration for the subjects concerned.

The fact that no significance occurred in the parameters of this study over the second five-week training program (Test II to Test III) can probably be explained by noting that the combined groups' mean maximal oxygen uptake of the subjects significantly improved at the .01 level of confidence over this same period. The second five weeks of training (Test II to Test III) may have produced enough exercise to help stabilize the parameters of cholesterol, percentage body fat, and body weight. It can also be postulated that the subjects were becoming accustomed to the training program and their diets became more stable causing the parameters to level off.

Finally, due to the results of this study and within its limitations, the investigator accepts the null hypothesis that there is no significant difference in changes of cholesterol and the selected anthropometric measurements among the six groups as a result of the conditioning program.

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[59]Swisher, loc. cit.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate the effects of selected training intensities and durations on improvement of cholesterol and selected anthropometric measurements.

The subjects were fifty-five college freshmen volunteers from the men's basic instruction physical education program at South Dakota State University. The study was carried out over a fourteen-week period. There were six training groups in the study and each group was assigned an experimental treatment. The groups were equated on the basis of a pre-test of maximal oxygen uptake. There were no controls placed on the outside activity or eating habits of the subjects. Data were collected prior to the start of the training program (Test I), after five weeks of training (Test II), and upon completion of the ten-week conditioning program (Test III).

The Least Squares Analysis of Variance method was used to conduct a statistical analysis of the data.[60] F ratios derived from the analysis of variance indicated that there was no significant difference among the groups for intensity, duration, or the interaction of the two variables. As none of the F ratios obtained were significant, the combined mean change of the entire six groups was analyzed using a t test. The t test

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[60]Robert G. D. Steel and James H. Torrie, Principles and Procedures of Statistics, (New York: McGraw-Hill Book Company, Inc., 1960), pp. 252-276.

results indicated that the combined mean change for cholesterol and percentage body fat increased significantly beyond the .01 level of confidence over the first five weeks of the training program (Test I to Test II). The combined mean increase for body weight was found to be significant at the .05 level of confidence over the same training period.

Conclusions

Due to the results of this study and within its limitations, the investigator concludes:

1. That the initial status of the subjects for maximal oxygen uptake (combined groups' mean of 49.60 ml./kg./min.) and cholesterol (combined groups' mean of 175 mg./100 ml.) was excellent.
2. The subjects significantly increased in cholesterol, percentage body fat, and body weight over the first five weeks of the training program (Test I to Test II). These same parameters leveled off and remained unchanged over the second five weeks of the training program (Test II to Test III).
3. No significant difference was found among the groups in effecting changes in cholesterol, percentage body fat, and body weight.

Recommendations

Based on the findings of this study, the investigator proposes the following recommendations for further study:

1. That a similar study be conducted utilizing a population with a

less desirable initial status for the parameters investigated in this study.

2. That a similar study be conducted using higher intensities and longer durations of exercise.
3. That a study be conducted where the effect of moderate and severe exercise on caloric intake and cholesterol levels are studied.

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APPENDICES

APPENDIX A

TABLE VI

RAW DATA FOR BODY WEIGHT

Subjects	Group	Test I	Test II	Test III
G.B.	I	156	158	158
R.G.	I	160	165	160
K.G.	I	172	171	177
P.J.	I	140	139	140
D.N.	I	153	155	157
S.P.	I	127	130	132
J.S.	I	134	135	137
L.U.	I	153	154	152
R.V.	I	191	192	188
Mean	I	154.00	155.44	155.66
M.B.	II	135	136	137
R.E.	II	178	181	180
J.E.	II	162	163	165
W.M.	II	146	147	146
T.R.	II	155	159	161
D.S.	II	140	136	137
C.S.	II	175	175	174
H.V.	II	140	138	139
B.W.	II	167	169	165
M.Z.	II	154	156	160
Mean	II	155.20	156.00	156.40
R.H.	III	156	155	153
B.J.	III	185	183	189
C.K.	III	150	156	151
D.L.	III	159	160	157
B.M.	III	166	166	168
D.V.	III	139	145	143
J.V.	III	179	178	178
Mean	III	162.00	163.29	162.71

TABLE VI

Subjects	Group	Test I	Test II	Test III
B.A.	IV	187	186	184
W.A.	IV	212	213	215
M.C.	IV	148	150	149
L.H.	IV	174	173	173
J.K.	IV	145	145	145
W.O.	IV	154	154	154
M.R.	IV	212	213	200
R.R.	IV	161	161	159
L.S.	IV	196	199	199
L.S.	IV	178	174	174
Mean	IV	176.70	176.80	175.20
T.B.	V	158	160	159
K.B.	V	176	176	175
R.B.	V	147	149	147
J.E.	V	127	130	125
M.F.	V	122	120	119
L.H.	V	148	152	153
D.I.	V	154	153	156
L.S.	V	156	160	155
D.T.	V	159	157	161
R.Z.	V	130	134	134
Mean	V	147.70	149.10	148.40
T.B.	VI	164	164	164
D.C.	VI	151	155	156
P.H.	VI	171	175	173
L.J.	VI	128	131	133
S.M.	VI	175	170	169
J.N.	VI	178	177	184
M.R.	VI	170	170	174
D.W.	VI	156	152	156
M.W.	VI	188	188	190
Mean	VI	164.55	164.67	166.56

APPENDIX B

TABLE VII

RAW DATA FOR CHOLESTEROL

Subjects	Group	Test I	Test II	Test III
G.B.	I	166	185	163
R.G.	I	171	156	183
K.G.	I	197	190	218
P.J.	I	202	241	243
D.N.	I	175	209	209
S.P.	I	218	241	221
J.S.	I	173	180	192
L.U.	I	163	177	182
R.V.	I	130	154	129
Mean	I	177.22	192.56	193.33
M.B.	II	186	166	215
R.E.	II	141	201	117
J.E.	II	175	190	177
W.M.	II	186	166	201
T.R.	II	171	182	191
D.S.	II	161	196	176
C.S.	II	188	182	193
H.V.	II	173	206	206
B.W.	II	161	170	209
M.Z.	II	194	231	250
Mean	II	173.60	189.00	193.50
R.H.	III	174	185	167
B.J.	III	213	267	236
C.K.	III	196	198	230
D.L.	III	205	250	192
B.M.	III	200	221	203
D.V.	III	166	170	175
J.V.	III	181	220	224
Mean	III	190.71	215.86	203.86

TABLE VII

Subjects	Group	Test I	Test II	Test III
B.A.	IV	159	170	172
W.A.	IV	143	154	156
M.C.	IV	193	192	191
L.H.	IV	171	148	190
J.K.	IV	141	144	170
W.O.	IV	201	206	237
M.R.	IV	186	225	206
R.R.	IV	161	207	142
L.S.	IV	191	231	190
L.S.	IV	122	137	125
Mean	IV	166.80	181.40	177.90
T.B.	V	176	180	185
K.B.	V	143	185	163
R.B.	V	185	192	185
J.E.	V	152	182	190
M.F.	V	147	132	168
L.H.	V	175	209	215
D.I.	V	208	195	212
L.S.	V	166	192	190
D.T.	V	141	168	166
R.Z.	V	183	200	224
Mean	V	167.60	183.50	189.80
T.B.	VI	173	182	190
D.C.	VI	188	187	170
P.H.	VI	191	185	227
L.J.	VI	143	156	170
S.M.	VI	135	180	198
J.N.	VI	166	156	209
M.R.	VI	219	203	230
D.W.	VI	194	190	221
M.W.	VI	191	211	198
Mean	VI	177.78	183.33	201.44

APPENDIX C

TABLE VIII

RAW DATA FOR PERCENTAGE BODY FAT

Subjects	Group	Test I	Test II	Test III
G.B.	I	15	16	16
R.G.	I	10	12	10
K.G.	I	17	17	19
P.J.	I	14	13	16
D.N.	I	10	12	13
S.P.	I	8	10	10
J.S.	I	21	21	21
L.U.	I	13	13	13
R.V.	I	21	23	21
Mean	I	14.33	15.22	15.44
M.B.	II	13	14	13
R.E.	II	26	25	25
J.E.	II	19	21	19
W.M.	II	13	13	13
T.R.	II	12	14	16
D.S.	II	20	17	18
C.S.	II	16	19	20
H.V.	II	13	11	11
B.W.	II	11	10	10
M.Z.	II	21	22	24
Mean	II	16.40	16.60	16.90
R.H.	III	10	9	9
R.J.	III	14	14	19
C.K.	III	17	19	18
D.L.	III	13	17	16
B.M.	III	17	19	19
D.V.	III	11	12	13
J.V.	III	24	25	27
Mean	III	15.14	16.43	17.29

TABLE VIII

Subjects	Group	Test I	Test II	Test III
B.A.	IV	12	13	11
W.A.	IV	18	20	18
M.C.	IV	24	25	25
L.H.	IV	16	18	21
J.K.	IV	10	10	9
W.O.	IV	21	19	18
M.R.	IV	27	28	25
R.R.	IV	17	19	20
L.S.	IV	21	22	22
L.S.	IV	20	19	18
Mean	IV	18.60	19.30	18.70
T.B.	V	14	13	16
K.B.	V	25	24	25
R.B.	V	19	19	20
J.E.	V	13	13	12
M.F.	V	11	12	13
L.H.	V	16	18	20
D.I.	V	11	10	10
L.S.	V	12	13	13
D.T.	V	16	15	16
R.Z.	V	13	12	11
Mean	V	15.00	14.90	15.60
T.B.	VI	15	15	15
D.C.	VI	17	16	20
P.H.	VI	15	17	16
L.J.	VI	12	13	13
S.M.	VI	11	12	12
J.N.	VI	17	17	17
M.R.	VI	25	25	26
D.W.	VI	10	11	11
M.W.	VI	20	22	21
Mean	VI	15.78	16.44	16.78